

HOW IT WORKS

Laser printers

It's quick, efficient and cost-effective, but how much do you really know about the workings of the laser printer? Tom Royal explores the blend of light and ink that make this machine print effortlessly

Inkjet printers are fine for most home users. They're small, cheap to buy and make printing letters, presentations and photos simple. If you want to print a lot of documents, however, most inkjets are unsuitable. Their small, pricy ink tanks need replacing often so they soon become expensive, and even the best inkjets are relatively slow. Waiting a few seconds for one copy of a letter isn't usually a problem, but when you're printing thousands of copies, the time quickly adds up.

This is why most businesses, and some home users, prefer to use laser printers. Lasers are much faster than inkjets, and their high-capacity toner supplies make them cost effective if you print lots of pages. Today a small laser printer can cost as little as £70 including VAT, but inside they rely on an ingenious mix of light, heat and electrostatic charge to create each page.

CHARGE OF THE LIGHT BRIGADE

Rather than squirting ink on to paper like an inkjet printer, laser printers use electric charge to attract dry powdered ink, known as toner, to the page. As with an inkjet, each page is built up from hundreds of horizontal lines. Once the printer has received the data to be printed, a raster image processor or RIP splits it into lines to be printed one by one.

At the heart of the printing process is a rotating imaging drum. This is made of a photoconductive material, which can hold static electricity until it is discharged by light. The first step towards printing each page is to charge the surface of this drum. Older printers use a technique called Corona discharge. Electricity at high voltage passes through a wire, ionising the air around it. Positive ions are drawn towards a charged wire shield, while negative ions and free electrons are propelled away and on to the drum. Newer laser printers tend to use a charged roller to pass this negative charge to the imaging drum.

Once part of the drum has been given this charge, part of the image to be printed is applied to it. This is accomplished by removing charge from areas of the drum using a laser beam. The laser shines on to a rotating polygonal mirror. As each side of the polygon passes through the laser, it sweeps the reflected beam across the surface of the imaging drum. As the reflected laser scans across the drum, it is turned on and off, depending on whether each part of the page should be black or white. Black areas are marked with the laser, which removes the negative charge from them. As it passes over white areas the laser is turned off, leaving the negative charge on the drum.

Some printers, such as those manufactured by Oki, use light-emitting diodes (LEDs) instead of a laser beam. A strip of LEDs is placed beside the drum. Each LED represents one dot on the paper, and each can be turned on and off individually to leave the corresponding point on the page black or white. This light-source system has the advantage of using fewer moving parts than a laser-based printer.

THE RULES OF ATTRACTION

Once it has passed the laser or LED light source, the drum contains an electrostatic image of the page to be printed. The next step is to apply ink to the relevant areas. Unlike an inkjet printer, which uses liquid ink from small cartridges, laser printers use a dry, powdered ink called toner.

Toner is a mixture of pigment, which creates the colour on the page, and other substances that bond it to the paper when it is heated. This powdered toner isn't deposited directly from the cartridge on to the imaging drum. Instead, the toner is given a negative charge and then picked up using a second roller, called the developer unit or jump roller. This metal roller is usually built into the toner cartridge itself, and is coated in particles that have a slight positive charge to attract the toner.

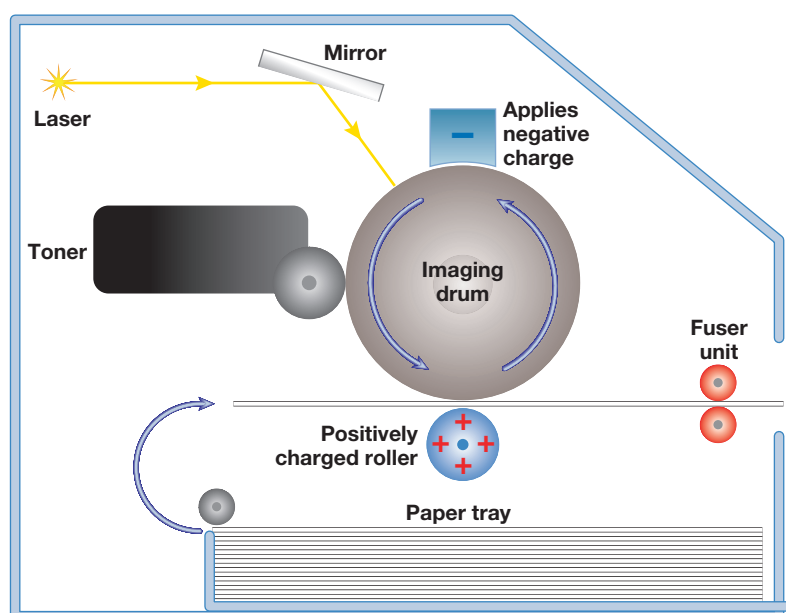
After passing the laser or LED, the imaging drum passes the toner-coated developer unit. A field applied in this area propels the negatively charged toner particles towards the image drum. The areas untouched by laser or LED light have a negative charge and repel these particles, leaving them on the developer unit. The areas that were discharged by the light have no charge and do not repel the particles, so toner is pushed on to these areas of the drum.

In a mono laser printer, the final step is to apply this ink to the paper. Rollers pull a sheet of paper from the input cassette and pass it between the imaging drum and another roller, which has a positive charge. This positive charge attracts the negatively charged toner particles, pulling them on to the page. The paper then carries the image or document that is being printed. Finally it passes between two heated rollers, known as the fuser unit. These melt the toner, bonding it to the paper. The page, which is usually still warm from the fuser, is fed out of the printer ready for use.

COLOUR SCHEME

The technique described here can print only a single colour, usually black, to each sheet of paper. There are several ways of implementing this technology to create a colour laser printer, however. The simplest design, known as a single-pass colour laser, is used in the fastest, more expensive models. More

MONO LASER PRINTER



▲ A laser builds up the image by discharging areas on a negatively charged imaging drum. The toner is repelled by the negative areas and clings to the discharged areas. This is transferred to the paper



affordable colour lasers use a slower, more economical method known as four-pass printing.

Like most inkjet printers, colour laser printers build up each page using four colours: cyan, magenta, yellow and black. A single-pass colour laser printer prints each colour in turn, using four separate toners, four separate image drums and four separate lasers. This arrangement is fast. If all four imaging drums inside such a device run at the same speed as that of a mono laser printer, the time it takes to print a colour page is barely longer than the time it takes for a mono printer to print a black-and-white one. Whether you print a colour or black-and-white document, it will appear quickly. Single-pass printers have several disadvantages, though. For one, the four lasers and four imaging drums make them expensive to buy. They also tend to be large and heavy.

Four-pass colour laser printers use four toner cartridges and four developer units but only one imaging drum and one laser. The four toner cartridges and their developer units are usually mounted in a revolving case known as a carousel. The carousel holds one toner and developer unit at a time next to the imaging drum and rotates through 90° to bring the next colour into place. Older four-pass colour lasers would send each sheet of paper past the imaging drum four times, one pass for each toner in the carousel. Moving the paper around this much has obvious disadvantages, as the page is far more likely to jam in the mechanism.

More modern four-pass lasers use a smarter system. Rather than passing toner from the imaging drum directly on to the page, these newer printers pass each colour image on to a revolving belt. All four colours are deposited on to the belt, which must be at least as large as the sheet of paper to be printed. Once all four colours are completed and a full colour image is on the belt, the entire image is passed from the belt to the sheet of paper in one go. The paper is then passed through the fuser unit and out of the printer. These four-pass laser printers are cheap to produce, as they require only one laser or LED unit and one imaging drum. They are also only a little larger than a mono laser printer.

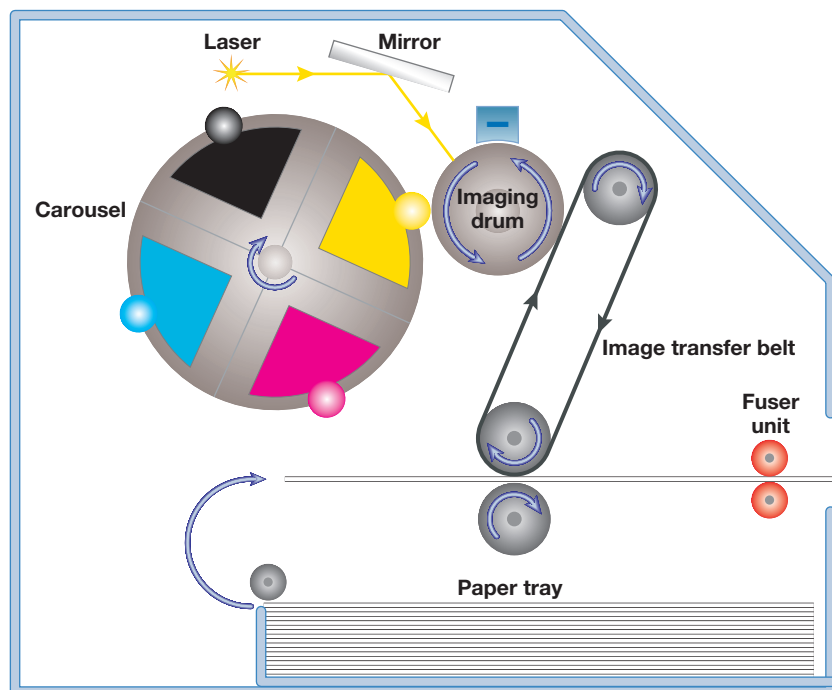
BEYOND RECOGNITION

One little-known aspect of colour laser printing is that many of the printers mark each document they create with hidden coded information. According to the Electronic Freedom Foundation (EFF), certain printers made by Brother, Canon, Dell, Epson, HP, IBM, Konica-Minolta, Kyocera, Lexmark, Ricoh and Xerox print codes on each page. Manufacturers notable for not doing so are Oki and Samsung.

The coded information is printed as a pattern of tiny yellow dots that are almost invisible to the naked eye. Researchers have found that they can make the dots easier to see by using a microscope and a blue LED light that shows up the yellow dots as dark blue. One researcher, Andrew Huang, was able to modify a scanner so that it could scan using only blue light and record the marks.

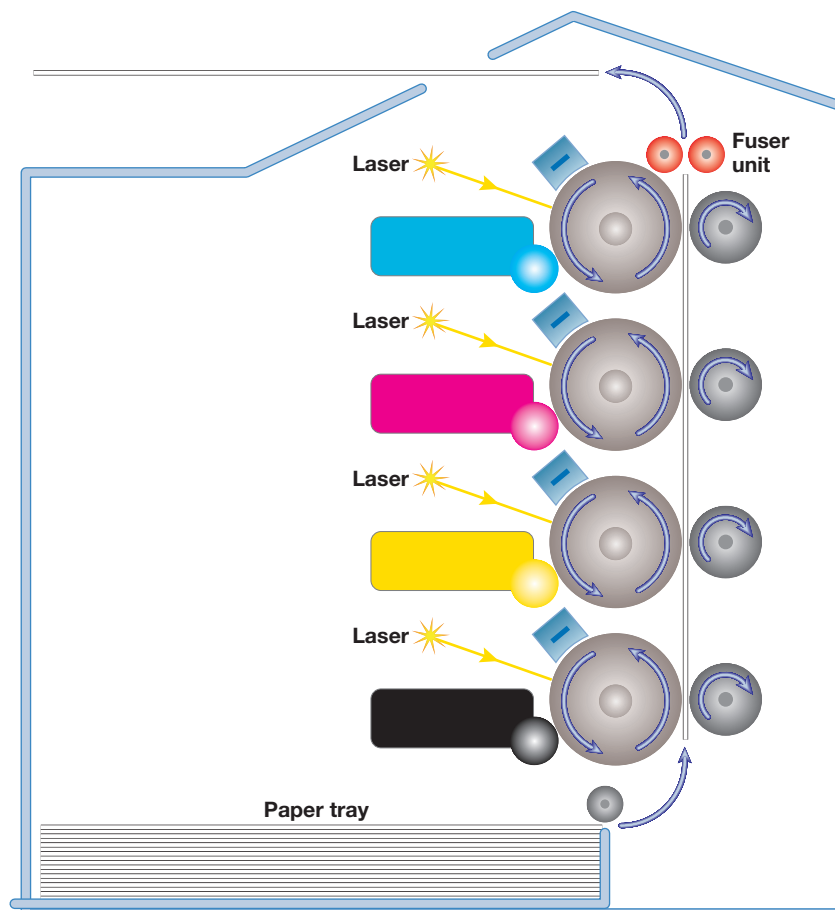
The EFF has been collecting test documents from a variety of printers and has been able to decode all but one of the encoded fields. This 7x15 grid of dots contains the date and time of printing and the printer's serial number, plus an unexplained value that is constant on every sheet printed by a given printer. **CS**

FOUR-PASS COLOUR LASER PRINTER



▲ Four-pass lasers use a single laser and imaging drum but four toner cartridges and developer units, which rotate on a carousel. This makes them slower than mono and single-pass colour lasers, but they're cheaper to produce

SINGLE-PASS COLOUR LASER PRINTER



▲ A single-pass colour laser printer uses four lasers and four imaging drums and can print a colour page almost as quickly as a mono laser printer can print a black-and-white one. Sadly, this also makes them large and expensive